Contents

Preface ix

SECTION I. MBE TECHNOLOGY AND APPLICATIONS

Applications of MBE grown PHEMTs
J.V. DiLorenzo, B. Lauterwasser and M.P. Zaitlin 1
Millimeterwave and digital applications of InP-based MBE grown HEMTs and HBTs
P. Greiling 8
Mass production of InAs Hall elements by MBE
I. Shibasaki 13
High power mid-infrared quantum cascade lasers with a molecular beam epitaxy grown InP cladding operating above room temperature
J. Faist, F. Capasso, C. Sirtori, D.L. Sivco, J.N. Baillargeon, A.L. Hutchinson, S.-N.G. Chu and A.Y. Cho 22
Progress and prospect of group-III nitride semiconductors
I. Akasaki and H. Amano 29
Solid-source MBE for growth of laser diode materials
M. Toivonen, P. Savolainen, H. Asonen and M. Pessa 37
Low threshold 1.3 μm InAsP/GaInAsP lasers grown by solid-source molecular beam epitaxy
C.C. Wamsley, M.W. Koch and G.W. Wicks 42
Solid source MBE growth and regrowth of 1.55 μm wavelength GaInAsP/InP ridge lasers
F.G. Johnson, O. King, F. Seiferth, S. Horst, D.R. Stone, R.D. Whaley, M. Dagenais and Y.J. Chen 46
Virtual control simulator for closed-loop epitaxial growth
J.J. Zhou, Y. Li, D. Pacheco, H.P. Lee and X. Liu 52
Sensor controlled linear motion oven (S-LIMO) for group III flux operation
P.P. Chow, K.R. Evans, A.J. SpringThorpe, P. Fisher, J.J. Klaassen, A. Wowchak and J. Van Hove 61
Improved MBE-grown GaAs using a novel, high-capacity Ga effusion cell
R.N. Sacks, P. Colombo, G.A. Patterson and K.A. Stair 66

SECTION II. NITRIDES

Growth of GaN, InGaN, and AlGaN films and quantum well structures by molecular beam epitaxy
M.A.L. Johnson, W.C. Hughes, W.H. Rowland, Jr., J.W. Cook, Jr., J.F. Schetzina, M. Leonard, H.S. Kong, J.A. Edmond and J. Zavada 72
Optimization of AlGaN films grown by RF atomic nitrogen plasma using in-situ cathodoluminescence
J.M. Van Hove, P.P. Chow, A.M. Wowchak, J.J. Klaassen, M.F. Rosamond and D.R. Croswell 79
Er doping of III-nitrides during growth by metalorganic molecular beam epitaxy
J.D. MacKenzie, C.R. Abernathy, S.J. Pearton, U. Hömmerich, X. Wu, R.N. Schwartz, R.G. Wilson and J.M. Zavada 84
Growth kinetics of GaN grown by gas-source molecular beam epitaxy
J.R. Jenny, R. Kaspi and K.R. Evans 89
Stability of surface reconstructions on hexagonal GaN grown by molecular beam epitaxy
P. Hacke, G. Feuillet, H. Okumura and S. Yoshida 94
Growth and p-type doping of GaN on c-plane sapphire by nitrogen plasma-assisted molecular beam epitaxy
M.C. Yoo, M.Y. Park, S.K. Kang, H.D. Cho and J.W. Lee 100
Surface crystal-structure of a GaN film as an in situ mask using MOMBE
S. Yoshida and M. Sasaki 107
Cathodoluminescence of GaN films grown under Ga and N rich conditions by radio-frequency-molecular beam epitaxy
S.H. Cho, U. Tanaka, T. Maruyama, K. Akimoto, H. Okumura and S. Yoshida 112
Studies of GaN layers grown on sapphire using an RF-source
T.G. Andersson, K. Nozawa and Y. Horikoshi 117
Blue and green electroluminescence from GaN/InGaN heterostructures
R. Averbeck, H. Tews, A. Graber and H. Riechert 122
Zinc blende GaN grown by radio frequency plasma assisted molecular beam epitaxy
H.D. Cho, N.H. Ko, S.H. Park, T.W. Kang, J.W. Han, K.S. Eom, S.H. Won and K.S. Jung 125

Initial growth stage of GaN on Si substrate by alternating source supply using dimethyl-hydrazine
A. Hashimoto, Y. Aiba, T. Motizuki, M. Ohkubo and A. Yamamoto 129
Relation between surface reconstruction transitions and growth kinetics of zincblende (0 0 1) GaN
O. Brandt, H. Yang, A. Yamada and K.H. Ploog 134
Gas source molecular beam epitaxy of cubic GaN/GaAs (0 0 1) using hydrazine
S.A. Nikishin, G.A. Seryogin, H. Temkin, V.G. Antipov, S.S. Ruvimov and A.V. Merkulov 139
N incorporation in GaN_xP_{1-x} and InN_xP_{1-x} using a RF N plasma source
W.G. Bi and C.W. Tu 145
Gas source MBE growth of GaN rich side of $GaN_{1-x}P_x$ using ion-removed ECR radical cell
K. Iwata, H. Asahi, K. Asami and S. Gonda 150

SECTION III. III–V MATERIALS: GROWTH KINETICS AND DOPING

Laterally nonuniform Ga segregation at GaAs/AlGaAs interfaces during MBE growth
W. Braun, A. Trampert, L. Däweritz and K.H. Ploog 156
Suppression of AlGaAs/GaAs superlattice intermixing by p-type doping
K. Muraki and Y. Horikoshi 162
InAs/GaAs in-plane strained superlattices grown on slightly misoriented (1 1 0) InP substrates by molecular beam epitaxy
Y. Nakata, O. Ueda, Y. Nishikawa, S. Muto and N. Yokoyama 168
Surface reconstruction and morphology evolution in highly strained InAs epilayer growth on GaAs(0 0 1) surface
Q. Xue, T. Ogino, H. Kiyama, Y. Hasegawa and T. Sakurai 174
Real space imaging of GaAs/AlAs (0 0 1) heterointerfaces
J. Behrend, M. Wassermeier, W. Braun, P. Krispin and K.H. Ploog 178
Control of chemical composition and band gap energy in $Ga_xIn_{1-x-y}Al_yAs$ on InP during molecular beam epitaxy
J.M. Schneider, J.-T. Pietralla and H. Heinecke 184
Properties of InAs thin films grown on (1 0 0)-oriented GaAs substrate with various tilted angles and directions of misorientation
M. Yamamoto, T. Iwabuchi, T. Ito, T. Yoshida, T. Isoya and I. Shibasaki 191
Low temperature (LT) and stoichiometric low temperature (SLT) MBE GaAs and related compounds: improved structural, electrical and optical properties
M. Missous and S. O'Hagan 197
Growth dynamics of InGaAs/GaAs by MBE
F. Fournier, R.A. Metzger, A. Doolittle, A.S. Brown, C. Carter-Coman, N.M. Jokerst and R. Bicknell-Tassius 203
A Monte Carlo study of gallium desorption kinetics during MBE of (1 0 0)-GaAs/AlGaAs heterostructures
K. Mahalingam, D.L. Dorsey, K.R. Evans and R. Venkatasubramanian 211
Re-entrant behavior of 2D to 3D morphology change and 3D island lateral size equalization via mass exchange in Stranski–Krastanow growth: InAs on GaAs(0 0 1)
T.R. Ramachandran, R. Heitz, N.P. Kobayashi, A. Kalburge, W. Yu, P. Chen and A. Madhukar 216
Heuristic rules for group IV dopant site selection in III–V compounds
R. Venkatasubramanian, D.L. Dorsey and K. Mahalingam 224
Surface segregation of Si in δ-doped $In_{0.53}Ga_{0.47}As$ grown by molecular beam epitaxy
B. Vögele, C.R. Stanley, E. Skuras, A.R. Long and E.A. Johnson 229
Two-dimensional limitations when increasing the Si-concentration from δ-doping to thin Si-layers in GaAs
J.V. Thordson, T.G. Andersson, G. Swenson and U. Södervall 234
Determination of $Al_xGa_{(1-x)}As$ composition: the MBE perspective
Z.R. Wasilewski, M.M. Dion, D.J. Lockwood, P. Poole, R.W. Streater and A.J. SpringThorpe 238

SECTION IV. IN SITU MONITORING AND CONTROL

Monitoring Ga and In desorption and In surface segregation during MBE using atomic absorption
A. Jackson, P. Pinsukanjana, L. Coldren and A. Gossard 244
Simultaneous in situ measurement of substrate temperature and layer thickness using diffuse reflectance spectroscopy (DRS) during molecular beam epitaxy
Y. Li, J.J. Zhou, P. Thompson, D. Pacheco, D.L. Sato, O. Arain and H.P. Lee 250
Application of pyrometric interferometry to the in situ monitoring of $In_{0.52}Al_{0.48}As$, $In_{0.53}Ga_{0.47}As$, and quaternary alloy growth on InP substrates
R.M. Sieg, R.N. Sacks and S.A. Ringel 256

Use of optical fiber pyrometry in molecular beam epitaxy
K.G. Eyink, J.K. Patterson, S.J. Adams, T.W. Haas and W.V. Lampert 262
Measurement of MBE substrate temperature by photoluminescence
Y. Takahira and H. Okamoto 267
Effect of substrate thickness, back surface texture, reflectivity, and thin film interference on optical band-gap thermometry
S.R. Johnson and T. Tiedje 273
Real time in-situ thickness control of Fabry–Perot cavities in MBE by 44 and 88 wavelength ellipsometry
C.H. Kuo, M.D. Boonzaayer, M.F. DeHerrera, D.K. Schroder, G.N. Maracas and B. Johs 281
Two-dimensional to one-dimensional mode change in GaAs molecular beam epitaxy revealed by in situ scanning electron microscopy
N. Inoue, Y. Kawamura, Y. Homma, J. Osaka, T. Araki and T. Ito 286
In situ observation of MEE GaAs growth using scanning electron microscopy
Y. Homma, H. Yamaguchi and Y. Horikoshi 292
A new in situ III–V surface characterization technique: chemical modulation spectroscopy
P.A. Postigo, T. Utzmeier, G. Armelles and F. Briones 298
Electronic properties of monolayer steps on GaAs (0 0 1) surfaces studied by scanning tunneling microscopy
K. Kanisawa, H. Yamaguchi and Y. Horikoshi 304
Evolution of short- and long-range order during Si incorporation on GaAs(0 0 1) observed by RAS and RHEED during MBE
L. Däweritz, K. Stahrenberg, P. Schützendübe, J.-T. Zettler, W. Richter and K.H. Ploog 310
A RHEED and STM study of Sb-rich AlSb and GaSb (0 0 1) surface reconstructions
P.M. Thibado, B.R. Bennett, B.V. Shanabrook and L.J. Whitman 317
Effects of morphology on photoemission oscillation measurements during growth of resonant tunneling devices
J.J. Zinck and D.H. Chow 323
Reflectivity difference spectroscopy study of thin film ZnSe grown on GaAs by molecular beam epitaxy
C.C. Kim, Y.P. Chen, M. Daraselia, S. Sivananthan, S.-C.Y. Tsen and D.J. Smith 328
Real-time monitoring of RHEED using machine vision techniques
R.F. Kromann, R.N. Bicknell-Tassius, A.S. Brown, J.F. Dorsey, K. Lee and G. May 334
In-situ BEEM study of interfacial dislocations and point defects
H. von Känel, T. Meyer and H. Sirringhaus 340
In situ STM characterisation of Ga^+ focused ion beam interactions with MBE grown GaAs(1 0 0)
S.J. Brown, P.D. Rose, E.H. Linfield, D.A. Ritchie, V. Drouot and G.A.C. Jones 346

SECTION V. VERTICAL CAVITY SURFACE EMITTING LASERS GROWTH

MBE growth of highly reproducible VCSELs
Y.M. Houng and M.R.T. Tan 352
Fabrication of InGaAs vertical-cavity surface-emitting lasers by molecular beam epitaxy on (4 1 1)A GaAs substrates and its room-temperature operation
Y. Hanamaki, T. Takeuchi, N. Ogasawara and Y. Shiraki 359
Growth of vertical cavity surface emitting laser material on (3 1 1)B GaAs by MBE
D.E. Mars, S.J. Rosner, Y. Kaneko, S. Nakagawa, T. Takeuchi and N. Yamada 365
Molecular beam epitaxy of AlGaAsSb system for 1.55 μm Bragg mirrors
J.C. Harmand, A. Kohl, M. Juhel and G. Le Roux 372
Carbon delta doping in chemical beam epitaxy using CBr_4
T.B. Joyce, T.J. Bullough, T. Farrell, B.R. Davidson, D.E. Sykes and A. Chew 377
Strain compensation in highly carbon doped GaAs/AlAs distributed Bragg reflectors
A. Mazuelas, R. Hey, M. Wassermeier and H. T. Grahn 383

SECTION VI. IN SITU PROCESSING: ETCHING AND REGROWTH

Improving the etched/regrown GaAs interface by in-situ etching using tris-dimethylaminoarsenic
N.Y. Li, Y.M. Hsin, P.M. Asbeck and C.W. Tu 387
Analysis of in-situ etched and regrown AlInAs/GaInAs interfaces
P. Chavarkar, D.S.L. Mui, T. Strand, L.A. Coldren and U.K. Mishra 393

Selective area epitaxy of GaAs using very low energy Ga^+ focused ion beam deposition combined with molecular beam epitaxial growth
H.E. Beere, J.H. Thompson, G.A.C. Jones and D.A. Ritchie 398
Selective area chemical beam epitaxial regrowth of Si-doped GaAs by using silicon tetraiodide for field effect transistor application
S. Izumi, Y. Yamamoto, T. Kunii, S. Miyakuni, N. Hayafuji, K. Sato and M. Otsubo 404
MBE regrowth on AlGaInAs DFB gratings using in-situ hydrogen radical cleaning
H. Künzel, J. Böttcher, A. Hase, H.-J. Hensel, K. Janiak, G. Urmann and A. Paraskevopoulos 411
Hydrogen radical surface cleaning of GaAs for MBE regrowth
T.M. Burke, E.H. Linfield, D.A. Ritchie, M. Pepper and J.H. Burroughes 416
Novel $Ga_2O_3(Gd_2O_3)$ passivation techniques to produce low D_{it} oxide-GaAs interfaces
M. Hong, J.P. Mannaerts, J.E. Bower , J. Kwo, M. Passlack, W-Y. Hwang and L.W. Tu 422
Iodine-assisted molecular beam epitaxy
M. Micovic, D. Lubyshev, W.Z. Cai, F. Flack, R.W. Streater, A.J. SpringThorpe and D.L. Miller 428
Passivation of misfit dislocations by atomic hydrogen irradiation in lattice-mismatched heteroepitaxy
M. Yokozeki, H. Yonezu, T. Tsuji and N. Ohshima 435
Formation of an n-GaAs/n-GaAs regrowth interface without carrier depletion using electron cyclotron resonance hydrogen plasma
T. Niwa, N. Furuhata and T. Maeda 441
High-temperature surface cleaning of AlGaAs without As flux for MBE regrowth
K. Iizuka, K. Matsumaru, T. Suzuki, Y. Takahira, T. Nishioka and H. Okamoto 447

SECTION VII. GROUP IV MATERIALS: Si, SiGe, AND SiC

Fabrication and band alignment of pseudomorphic $Si_{1-y}C_y$, $Si_{1-x-y}Ge_xC_y$ and coupled $Si_{1-y}C_y/Si_{1-x-y}Ge_xC_y$ quantum well structures on Si substrates
K. Brunner, W. Winter, K. Eberl, N.Y. Jin-Phillipp and F. Phillipp 451
MBE growth and structural characterization of $Si_{1-y}C_y/Si_{1-x}Ge_x$ superlattices
S. Zerlauth, J. Stangl, A.A. Darhuber, V. Holý, G. Bauer and F. Schäffler 459
Why is a quantum-confined Stark shift absent in type-I strained $Si_{1-x}Ge_x$/Si symmetric quantum wells?
Y. Miyake, J.Y. Kim, Y. Shiraki and S. Fukatsu 465
Sidewall faceting and inter-facet mass transport in selectively grown epitaxial layers on SiO_2-masked Si(1 1 0) substrates
Q. Xiang, S. Li, D. Wang, K. Sakamoto, K.L. Wang, G. U'Ren and M. Goorsky 469
Enhancement of substitutional carbon incorporation in hydrogen-mediated pseudomorphic growth of strained alloy layers on Si(0 0 1)
G. Lippert, P. Zaumseil, H.J. Osten and M. Kim 473
New hydrogen desorption kinetics from vicinal Si(0 0 1) surfaces observed by reflectance anisotropy spectroscopy
J. Zhang, A.K. Lees, A.G. Taylor, M.H. Xie, B.A. Joyce, Z. Sobiesierksi and D.I. Westwood 477
Reduction of SiGe heterointerface mixing by atomic hydrogen irradiation during molecular beam epitaxy and its mechanism
K. Nakagawa, Y. Kimura and M. Miyao 481
Control of composition and crystallinity in the molecular beam epitaxy of strain-compensated $Si_{1-x-y}Ge_xC_y$ alloys on Si
E.T. Croke, A.T. Hunter, C.C. Ahn, T. Laursen, D. Chandrasekhar, A.E. Bair, D.J. Smith and J.W. Mayer 486
Stratified suspension of highly ordered Si nanoparticles in SiO_2 created by Si MBE with oxygen co-implantation
Y. Ishikawa, N. Shibata and S. Fukatsu 493
Characterization of mismatched SiGe grown on low temperature Si buffer layers by molecular beam epitaxy
K.K. Linder, F.C. Zhang , J.-S. Rieh and P. Bhattacharya 499
Hybrid MBE growth and mobility limiting factors of *n*-channel Si/SiGe modulation-doped systems
A. Yutani and Y. Shiraki 504
Effect of Hydrogen on the growth kinetics of Si(0 0 1) during GSMBE from disilane
K. Mizushima, D.D. Vvedensky, P. Šmilauer, A. Zangwill, J. Zhang and B.A. Joyce 509
Visible light emission from MBD-grown Si/SiO_2 superlattices
S.V. Novikov, J. Sinkkonen, O. Kilpelä and S.V. Gastev 514
Luminescence study on Ge islands as stressors on $Si_{1-x}Ge_x$/Si quantum well
E.S. Kim, N. Usami, H. Sunamura, S. Fukatsu and Y. Shiraki 519
The growth and luminescence of SiGe dots
H. Chen, X.G. Xie, W.Q. Cheng, Q. Huang and J.M. Zhou 524

Characterization of homoepitaxial SiC layers
J. Schmitt, T. Troffer, K. Christiansen, M. Schadt, S. Christiansen, R. Helbig, G. Pensl and H.P. Strunk 528

SECTION VIII. II–VI MATERIALS

II–VI light-emitting devices based on beryllium chalcogenides
F. Fischer, G. Landwehr, Th. Litz, H.J. Lugauer, U. Zehnder, Th. Gerhard, W. Ossau and A. Waag 532
Molecular beam epitaxial growth of lattice-matched $Zn_xCd_yMg_{1-x-y}Se$ quaternaries on InP substrates
L. Zeng, A. Cavus, B.X. Yang, M.C. Tamargo, N. Bambha, A. Gray and F. Semendy 541
Surface preparation of ZnSe substrates for MBE growth of II–VI light emitters
W.C. Hughes, C. Boney, M.A.L. Johnson, J.W. Cook, Jr. and J.F. Schetzina 546
Reduction of extended defects in II–VI blue–green laser diodes
T.B. Ng, C.C. Chu, J. Han, G.C. Hua, R.L. Gunshor, E. Ho, E.L. Warlick, L.A. Kolodziejski and A.V. Nurmikko 552
Optimized growth of lattice-matched ZnCdSe epilayers on InP substrates
A. Cavus, L. Zeng, B.X. Yang , N. Dai, M.C. Tamargo, N. Bambha and F. Semendy 558
Reducing the defect density in MBE-ZnSe/III–V heterostructures
E.L. Warlick, E. Ho, G.S. Petrich and L.A. Kolodziejski 564
Investigation of the structural properties of MBE grown ZnSe/GaAs heterostructures
I. Hernández-Calderón, E. López-Luna, J. Luyo, M. Meléndez-Lira, O. de Melo, P. Díaz, L. Hernández, J. Fuentes, R. León and H. Sitter 571
ZnSe homoepitaxial growth on solid-phase recrystallized substrates
E. Tournié, P. Brunet, C. Ongaretto, C. Morhain, J.-P. Faurie, R. Triboulet and J.O. Ndap 577
MBE growth of n-type ZnSe and ZnS using ethylchloride as a dopant
T. Yasuda, B.-P. Zhang and Y. Segawa 583
Growth mechanism of II–VI compound semiconductors by molecular beam epitaxy
H. Okuyama, T. Kawasumi, A. Ishibashi and M. Ikeda 587
Hydrogen sulfide treatment of GaAs substrate and its effects on initial stage of ZnSe growth
J. Suda, R. Tokutome, Y. Kawakami, Sz. Fujita and Sg. Fujita 593
Homogeneous and δ-doped ZnS:Mn grown by MBE
S. Schön, M. Chaichimansour, W. Park, T. Yang, B.K. Wagner and C.J. Summers 598
Electrical characterization of engineered ZnSe–GaAs heterojunction diodes
M. Lazzeri, V. Pellegrini, F. Beltram, M. Lazzarino, J.J. Paggel, L. Sorba, S. Rubini, A. Bonanni and A. Franciosi 603
Molecular beam epitaxial growth of ZnSe(1 1 1) films on GaAs(1 1 1)B substrates and nitrogen doping
N. Matsumura, T. Matsuoka, H. Shimakawa and J. Saraie 608
Molecular beam epitaxial growth of ZnSe on GaAs substrates: influence of precursors on interface quality
C.C. Kim, Y.P. Chen, S. Sivananthan, S.-C.Y. Tsen and D.J. Smith 613
p-Type doping of beryllium chalcogenides grown by molecular beam epitaxy
H.-J. Lugauer, Th. Litz, F. Fischer, A. Waag, T. Gerhard, U. Zehnder, W. Ossau and G. Landwehr 619
Molecular beam epitaxy of BeTe on vicinal Si(1 0 0) Surfaces
X. Zhou, S. Jiang and W.P. Kirk 624
Blue-light emission from ZnSTe-based EL devices
I.K. Sou, J. Mao, Z. Ma, W.S. Chen, Z. Yang, K.S. Wong and G.K.L. Wong 632
Room-temperature continuous-wave operation of ZnSe-based blue–green laser diode grown by molecular beam epitaxy
Moon-Deock Kim, Bong-Jin Kim, Min-Hyon Jeon, Jeong-Keun Ji, Sang-Dong Lee, Eun-Soon Oh, Jin-Suck Kim, Hae-Sung Park and Tae-Il Kim 637
Growth and characterization of lattice-matched HgSe
L. Parthier, H. Wißmann, S. Luther, G. Machel, M. Schmidbauer, R. Köhler and M. von Ortenberg 642
p-Type doping with arsenic in (2 1 1)B HgCdTe grown by MBE
P.S. Wijewarnasuriya, F. Aqariden, C.H. Grein, J.P. Faurie and S. Sivananthan 647
High performance HgCdTe two-color infrared detectors grown by molecular beam epitaxy
R.D. Rajavel, D.M. Jamba, O.K. Wu, J.E. Jensen, J.A. Wilson, E.A. Patten, K. Kosai, P. Goetz, G.R. Chapman and W.A. Radford 653
Ellipsometric analysis of CdZnTe preparation for HgCdTe MBE growth
J.D. Benson, A.B. Cornfeld, M. Martinka, J.H. Dinan, B. Johs, P. He and J.A. Woollam 659
Molecular beam epitaxial growth of the CdMnTe/CdTe superlattices on (100) GaAs substrates
M. Yano, K. Koike, T. Furushou and T. Yodo 665

Elastic and plastic deformation in low mismatched $Cd_xHg_{1-x}Te/Cd_{1-y}Zn_yTe$
T. Colin, T. Skauli and S. Løvold 670
A study of MBE growth and thermal annealing of p-type long wavelength HgCdTe
L. He, J.R. Yang, S.L. Wang, S.P. Guo, M.F. Yu, X.Q. Chen, W.Z. Fang, Y.M. Qiao, Q.Y. Zhang, R.J. Ding and T.L. Xin 677
Nitrogen doping of Te-based II–VI compounds
S. Tatarenko, T. Baron, A. Arnoult, J. Cibert, M. Grün, A. Haury, Y. Merle d'Aubigné, A. Wasiela and K. Saminadayar 682

SECTION IX. QUANTUM DOTS

Low-threshold injection lasers based on vertically coupled quantum dots
V.M. Ustinov, A.Yu. Egorov, A.R. Kovsh, A.E. Zhukov, M.V. Maximov, A.F. Tsatsul'nikov, N.Yu. Gordeev, S.V. Zaitsev, Yu.M. Shernyakov, N.A. Bert, P.S. Kop'ev, Zh.I. Alferov, N.N. Ledentsov, J. Böhrer, D. Bimberg, A.O. Kosogov, P. Werner and U. Gösele 689
Overgrowth of InGaAs quantum dots formed by alternating molecular beam epitaxy
R.P. Mirin, J.P. Ibbetson, J.E. Bowers and A.C. Gossard 696
Self-assembling InP quantum dots for red lasers
K. Eberl, A. Kurtenbach, M. Zundel, J.Y. Jin-Phillipp, F. Phillipp, A. Moritz, R. Wirth and A. Hangleiter 702
Increased size uniformity through vertical quantum dot columns
G.S. Solomon, S. Komarov, J.S. Harris, Jr. and Y. Yamamoto 707
Self-assembled structures of closely stacked InAs islands grown on GaAs by molecular beam epitaxy
Y. Nakata, Y. Sugiyama, T. Futatsugi and N. Yokoyama 713
Room temperature luminescence from self-organized $In_xGa_{1-x}As/GaAs$ ($0.35 < x < 0.45$) quantum dots with high size uniformity
K. Kamath, P. Bhattacharya and J. Phillips 720
Growth and characterization of self-organized InSb quantum dots and quantum dashes
T. Utzmeier, J. Tamayo, P.A. Postigo, R. García and F. Briones 725
MBE growth of novel GaAs/n-AlGaAs field-effect transistor structures with embedded InAs quantum traps and their transport characteristics
G. Yusa and H. Sakaki 730
In situ RHEED control of direct MBE growth of Ge quantum dots on Si (0 0 1)
V.A. Markov, A.I. Nikiforov and O.P. Pchelyakov 736
Growth controlled fabrication and cathodoluminescence study of 3D confined GaAs volumes on non-planar patterned GaAs(0 0 1) substrates
A. Konkar, H.T. Lin, D.H. Rich, P. Chen and A. Madhukar 741
Manipulating InAs island sizes with chemical beam epitaxy growth on GaAs patterns
M.S. Miller, L. Landin, S. Jeppesen, A. Petersson, I. Maximov, B. Kowalski and L. Samuelson 747
Self-organized quantum dot structures in strained $(GaP)_n(InP)_m$ short period superlattices grown on GaAs (N 1 1) by gas-source MBE
S.J. Kim, H. Asahi, M. Takemoto, K. Asami, J.H. Noh and S. Gonda 754
Intersubband absorption from $In_{0.26}Ga_{0.74}As/GaAs$ quantum dot superlattice
D. Pan, Y.P. Zeng, J.M. Li, C.H. Zhang, M.Y. Kong, H.M. Wang, C.Y. Wang and J. Wu 760
Molecular-beam epitaxy of self-assembled InAs quantum dots on non-(1 0 0) oriented GaAs
P.P. González-Borrero, E. Marega, Jr., D.I. Lubyshev, E. Petitprez and P. Basmaji 765
InAs/GaAs self-assembled quantum dots grown by ALMBE and MBE
A. Bosacchi, P. Frigeri, S. Franchi, P. Allegri and V. Avanzini 771
Formation of self-organized $In_{0.5}Ga_{0.5}As$ quantum dots on GaAs by molecular beam epitaxy
Jen-Inn Chyi, Tzer-En Nee, Ching-Ting Lee, Jia-Lin Shieh and Jen-Wei Pan 777
MBE growth and magnetotunnelling transport properties of a single GaAs/AlAs/GaAs barrier incorporating InAs quantum dots
M. Henini, I.E. Itskevich, T. Ihn, P. Moriarty, A. Nogaret, P.H. Beton, L. Eaves, P.C. Main, J.R. Middleton and J.S. Chauhan 782

SECTION X. QUANTUM WIRES

Selective MBE growth of GaAs wire and dot structures using atomic hydrogens and their electronic properties
T. Noda, Y. Nagamune, Y. Ohno, S. Koshiba and H. Sakaki 787

Molecular beam epitaxial growth of InGaAs/InGaAsP quantum wires on V-grooved InP substrates with (1 1 1) sidewalls
J. Wang, D.A. Thompson, B.J. Robinson and J.G. Simmons 793
Vertically stacked quantum wires fabricated by an in situ processing technique
M. López-López and T. Ishikawa 799
UHV-AFM study of MBE-grown 10 nm scale ridge quantum wires
S. Koshiba, I. Tanaka, Y. Nakamura, I. Kamiya, T. Someya, T. Ngo and H. Sakaki 804
Improved optical qualities of GaAs/$Al_{0.3}Ga_{0.7}As$ tilted T-shaped quantum wires fabricated by glancing-angle molecular beam epitaxy
N. Tomita, T. Kishi, K. Takekawa, K. Fujita, T. Watanabe, A. Adachi, S. Shimomura and S. Hiyamizu 809
High-density GaAs/$(GaAs)_2(AlAs)_2$ quantum wires naturally formed on (7 7 5)B-oriented GaAs substrates by molecular beam epitaxy
M. Higashiwaki, M. Yamamoto, S. Shimomura, A. Adachi and S. Hiyamizu 814
Growth of GaInAsP quantum wire heterostructures using the strain-induced lateral-layer ordering process
A.M. Moy, A.C. Chen, K.Y. Cheng, L.J. Chou and K.C. Hsieh 819

SECTION XI. ANTIMONIDE MATERIALS

MBE growth of high-power InAsSb/InAlAsSb quantum-well diode lasers emitting at 3.5 μm
G.W. Turner, M.J. Manfra, H.K. Choi and M.K. Connors 825
Microstructural properties of InAs/$InAs_xSb_{1-x}$ superlattices and $InAs_xSb_{1-x}$ ordered alloys grown by modulated molecular beam epitaxy
Y.-H. Zhang, A. Lew, E. Yu and Y. Chen 833
Sb-surface segregation and the control of compositional abruptness at the GaAsSb/GaAs interface
R. Kaspi and K.R. Evans 838
MBE growth of Si-doped InAlAsSb layers lattice-matched with InAs
M. Kudo and T. Mishima 844
Molecular beam epitaxial growth of GaInSbBi for infrared detector applications
Q. Du, J. Alperin and W.I. Wang 849
Large mismatch heteroepitaxy of InSb on Si(1 1 1) substrates using CaF_2 buffer layers
W.K. Liu, X.M. Fang, J. Winesett, W. Ma, X. Zhang, M.B. Santos and P.J. McCann 853
Indium antimonide doped with manganese grown by molecular beam epitaxy
D.L. Partin, J. Heremans and C.M. Thrush 860
Molecular beam epitaxial growth of high electron mobility InAs/AlGaAsSb deep quantum well structures
N. Kuze, H. Goto, M. Matsui, I. Shibasaki and H. Sakaki 868
MBE growth and characterization of high-quality GaInAsSb/AlGaAsSb strained multiple quantum well structures
A.Z. Li, Y. Zhao, Y.L. Zheng , G.T. Chen, G.P. Ru, W.Z. Shen and J.Q. Zhong 873
MBE growth of GaInAsSb p/n junction diodes for thermophotovoltaic applications
P.N. Uppal, G. Charache, P. Baldasaro, B. Campbell, S. Loughin, S. Svensson and D. Gill 877
Molecular-beam-epitaxial growth of $Ga_{1-x}In_xSb$ on GaAs substrates
J.H. Roslund, O. Zsebők, G. Swenson and T.G. Andersson 883
Stranski–Krastanov growth of InSb, GaSb, and AlSb on GaAs: structure of the wetting layers
B.R. Bennett, B.V. Shanabrook, P.M. Thibado, L.J. Whitman and R. Magno 888
Buffer-dependent mobility and morphology of InAs/(Al,Ga)Sb quantum wells
M. Thomas, H.-R. Blank, K.C. Wong and H. Kroemer 894

SECTION XII. DEVICES: ELECTRICAL-BASED

Molecular beam epitaxy of vertically compact $Al_xGa_{1-x}As$/GaAs laser-HEMT structures for monolithic integration
A. Gaymann, J. Schaub, W. Bronner, N. Grün, J. Hornung and K. Köhler 898
MBE growth of quaternary InGaAlAs layers in InGaAs/InAlAs HBTs to improve device performance
T.R. Block, J. Cowles, L. Tran, M. Wojtowicz, A.K. Oki and D.C. Streit 903
Improved hole transport properties of highly strained $In_{0.35}Ga_{0.65}As$ channel double-modulation-doped structures grown by MBE on GaAs
M. Kudo, H. Matsumoto, T. Tanimoto, T. Mishima and I. Ohbu 910
MBE growth of double-sided doped InAlAs/InGaAs HEMTs with an InAs layer inserted in the channel
M. Sexl, G. Böhm, D. Xu, H. Heiß, S. Kraus, G. Tränkle and G. Weimann 915

Resonant tunnelling of holes in double barrier heterostructures grown by MBE on (1 1 0) oriented GaAs substrates
M. Henini, R.K. Hayden, T. Takamasu, N. Miura, L. Eaves and G. Hill 919
GaAs/AlAs resonant tunneling diodes with super-flat interfaces grown on (4 1 1)A GaAs substrates by MBE
K. Shinohara, K. Kasahara, S. Shimomura, A. Adachi, N. Sano and S. Hiyamizu 924
Photoluminescence characterization of MBE grown AlGaAs/InGaAs/GaAs pseudomorphic HEMTs
M. Wojtowicz, D. Pascua, A.-C. Han, T.R. Block and D.C. Streit 930

SECTION XIII. DEVICES: OPTICAL-BASED

Multispectral InGaAs/GaAs/AlGaAs laser arrays by MBE growth on patterned substrates
K. Kamath, P. Bhattacharya and J. Singh 935
MBE growth of high-quality InP for GaInAs/InP heterostructures using incongruent evaporation of GaP
H. Künzel, J. Böttcher, P. Harde and R. Maessen 940
Gas-source molecular beam epitaxial growth of low threshold current 1.3 μm InAsP/InGaAsP lasers
P. Thiagarajan, G.E. Giudice, H. Temkin and G.Y. Robinson 945
High temperature (Ga)InAsP/high band gap GaInAsP barriers 1.3 μm SL-MQW lasers grown by gas source MBE
Ph. Pagnod-Rossiaux, F. Gaborit, N. Tscherptner, L. Roux, C. Starck and B. Fernier 948
MBE grown mid-infrared type-II quantum-well lasers
C.-H. Lin, S.J. Murry, D. Zhang, P.C. Chang, Y. Zhou, S.S. Pei, J.I. Malin, C.L. Felix, J.R. Meyer, C.A. Hoffman and J.F. Pinto 955
Waveguide modulator structures with soft optical confinement grown by the epitaxial shadow mask (ESM) MBE-technique
S. Malzer, W. Geißelbrecht, U. Hilburger, M. Kneissl, P. Kiesel, R. Mayer and G.H. Döhler 960
The growth and characterization of two new P-type compressively strained layer InGaAs/AlGaAs/GaAs quantum well infrared photodetectors for mid- and long-wavelength infrared detection
J. Chu, S.S. Li and P. Ho 964
Large array of GaAs modulators and detectors flip-chip solder bonded to silicon CMOS using InGaP as the selective etch stop for GaAs substrate removal
J.M. Kuo, Y.C. Wang, K.W. Goossen, L.M.F. Chirovsky, S.P. Hui, B.T. Tseng, J. Walker, A.L. Lentine, R.E. Leibenguth, G. Livescu, W.Y. Jan, J.E. Cunningham, L.A. D'Asaro, A. Ron, D. Dahringer, D. Kossives, D.D. Bacon, R.L. Morrison, R.A. Novotny, D.B. Buchholz and W.E. Mayo 971
Molecular beam epitaxy of strain-compensated InGaAs/GaAsP quantum-well intersubband photodetectors
K. Bacher, S. Massie and M. Seaford 977
MBE growth and characterization of doped multiple quantum well avalanche photodiodes
H.M. Menkara, R.N. Bicknell-Tassius, R. Benz, II, and C.J. Summers 983
Low dark current AlGaInAs/InP waveguide photodiodes using hybrid MBE and MOCVD growth
K. Nishikata, H. Shimizu, K. Hiraiwa, S. Yoshida, N. Yamanaka, M. Irikawa and A. Kasukawa 990
Improved electroabsorption properties in 1.3 μm MQW waveguide modulators by a modified doping profile
X.B. Mei, K.K. Loi, W.S.C. Chang and C.W. Tu 994
Investigation of Si-doped p-type AlGaAs/GaAs, AlGaAs/InGaAs quantum well infrared photodetectors and multiquantum wells grown on (3 1 1)A GaAs
A. Chin, C.C. Liao, J. Chu and S.S. Li 999
808 nm high-power laser grown by MBE through the control of Be diffusion and use of superlattice
Donghai Zhu, Zhanguo Wang, Jiben Liang, Bo Xu, Zhanping Zhu, Jun Zhang, Qian Gong and Shengying Li 1004

SECTION XIV. HETEROEPITAXY: METAMORPHIC, MAGNETIC, AND OTHER MATERIALS

Continuously graded buffers for InGaAs/GaAs structures grown on GaAs
A. Bosacchi, A.C. De Riccardis, P. Frigeri, S. Franchi, C. Ferrari, S. Gennari, L. Lazzarini, L. Nasi, G. Salviati, A.V. Drigo and F. Romanato 1009
Molecular beam epitaxy growth and characterization of $In_xGa_{1-x}As$ ($0.57 \leqslant x \leqslant 1$) on GaAs using InAlAs graded buffer
S.M. Wang, C. Karlsson, N. Rorsman, M. Bergh, E. Olsson, T.G. Andersson and H. Zirath 1016
Improved nucleation and spiral growth of PbTe on BaF_2 (1 1 1)
A.Y. Ueta, G. Springholz and G. Bauer 1022
Molecular beam epitaxy of $Al_{0.48}In_{0.52}As/Ga_{0.47}In_{0.53}As$ heterostructures on metamorphic $Al_xGa_yIn_{1-x-y}As$ buffer layers
M. Haupt, K. Köhler, P. Ganser, S. Müller and W. Rothemund 1028
Incorporation of As_2 in $InAs_xP_{1-x}$ and its application to $InAs_xP_{1-x}$/InP quantum well structures
M. Hopkinson and J.P.R. David 1033

Growth of abrupt GaAs/Ge heterointerfaces by atomic hydrogen-assisted molecular beam epitaxy
Y. Okada, J.S. Harris, Jr., A. Sutoh and M. Kawabe 1039
Growth and characterization of In_2Se_3 epitaxial films by molecular beam epitaxy
T. Okamoto, A. Yamada and M. Konagai 1045
Effects of strain on the growth and properties of $CuInSe_2$ epitaxial films
S. Niki, P.J. Fons, H. Shibata, T. Kurafuji, A. Yamada, Y. Okada, H. Oyanagi, W.G. Bi and C.W. Tu 1051
MBE growth of PbSe/CaF_2/Si(1 1 1) heterostructures
P.J. McCann, X.M. Fang, W.K. Liu, B.N. Strecker and M.B. Santos 1057
(GaMn)As:GaAs-based III–V diluted magnetic semiconductors grown by molecular beam epitaxy
T. Hayashi, M. Tanaka, T. Nishinaga, H. Shimada, H. Tsuchiya and Y. Otuka 1063
Epitaxy of (Ga, Mn)As, a new diluted magnetic semiconductor based on GaAs
A. Shen, H. Ohno, F. Matsukura, Y. Sugawara, N. Akiba, T. Kuroiwa, A. Oiwa, A. Endo, S. Katsumoto and Y. Iye 1069

SECTION XV. MBE GROWTH ON VICINAL SUBSTRATES

Growth parameter dependence of step patterns in AlGaAs molecular beam epitaxy on vicinal GaAs(1 1 0) inclined toward (1 1 1)A
S. Hasegawa, K. Sato, S. Torii and H. Nakashima 1075
Effects of tensile strain and substrate off-orientation on the growth of GaInAs/InP multiple quantum well structures by CBE
T. Marschner, R.T.H. Rongen, M.R. Leys, F.D. Tichelaar, H. Vonk and J.H. Wolter 1081
Organized growth of GaAs/AlAs lateral superlattices on vicinal surfaces: where are the limits?
F. Laruelle, F. Lelarge, Z.Z. Wang, T. Mélin, A. Cavanna and B. Etienne 1087
Formation of multi-atomic steps and novel n-AlGaAs/GaAs heterojunctions on vicinal (1 1 1)B substrates by MBE and anisotropic transport of 2D electrons
Y. Nakamura, S. Koshiba and H. Sakaki 1092
MBE growth of two-dimensional electron gases on (110) GaAs
C.B. Sørensen, H. Gislason and J.M. Hvam 1097
The building up of terrace periodicity by MBE growth on (0 0 1) GaAs vicinal surfaces
F. Lelarge, Z.Z. Wang, A. Cavanna, F. Laruelle and B. Etienne 1102
Photoluminescence investigation of p-type Si-doped AlGaAs grown by molecular beam epitaxy on (1 1 1)A, (2 1 1)A and (3 1 1)A GaAs surfaces
M. Henini, N. Galbiati, E. Grilli, M. Guzzi and L. Pavesi 1108
Patterned growth on GaAs (3 1 1)A substrates
R. Nötzel, J. Menniger, M. Ramsteiner, A. Trampert, H.-P. Schönherr, L. Däweritz and K.H. Ploog 1114

SECTION XVI. SINGLE AND MULTIPLE QUANTUM WELLS

Strain-balanced AlGaInAs/InP heterostructures with up to 50 QWs by MBE
H. Hillmer, R. Lösch and W. Schlapp 1120
New route to reduce ionized impurity scattering in modulation-doped GaAs quantum wells
R. Hey, K.-J. Friedland, H. Kostial, R. Klann and H.K. Ploog 1126
The growth of AlGaAs–InGaAs quantum-well structures by molecular beam epitaxy: observation of critical interdependent effects utilizing the design of experiments approach
R.N. Bicknell-Tassius, K. Lee, A.S. Brown, G. Dagnall and G. May 1131
MBE growth and physics of strongly coupled p-type double quantum wells showing correlated $\nu = 1$ quantum Hall state
M. Henini, R.J. Hyndman, T. Ihn, B.L. Gallagher, T.J. Foster, J.S. Chauhan and J.R. Middleton 1138
Photoluminescence study of Si/SiGe multiple quantum wells grown by MBE
D. Grützmacher, R. Hartmann, E. Müller, U. Gennser and A. Dommann 1144
Photoluminescence spectra of shadow masked multiple quantum wells
S. Sopitpan, P. Cheewatas, S. Thainoi, S. Ratanathammaphan and S. Panyakeow 1152
Radiative decay in type-II GaP/AlP/GaP quantum wells
S. Nagao, K. Fujii, T. Fujimori, H. Gotoh, H. Ito and F. Minami 1157
Temperature-insensitive photoluminescence above 300 K in strained Ga_xIn_{1-x} As multiple quantum wire heterostructures
D.E. Wohlert, S.T. Chou and K.Y. Cheng 1162

Growth-mode-induced surface morphology and its relation to optical properties of GaAs single quantum wells
R. Hey, I. Gorbunova, M. Ramsteiner, M. Wassermeier, L. Däweritz and K.H. Ploog 1167
Photoluminescence of low-temperature AlGaAs/GaAs multiple quantum wells
W. Feng, F. Chen, Q. Huang and J.M. Zhou 1173

SECTION XVII. GAS SOURCE MBE: MOMBE AND CBE

Surface chemistry during metalorganic molecular beam epitaxy studied by pulsed molecular beam scattering
M. Sasaki and S. Yoshida 1178
Lateral coupling of InP/GaInAsP/InP structures by selective area MOMBE
M. Wachter, U. Schöffel, M. Schier and H. Heinecke 1186
New semiconductors TlInGaP and their gas source MBE growth
H. Asahi, M. Fushida, K. Yamamoto, K. Iwata, H. Koh, K. Asami, S. Gonda and K. Oe 1195
CBE of 1.55 μm (GaIn)(AsP) lasers for monolithic integration
A. Nutsch, B. Torabi, H. Kratzer, G. Tränkle and G. Weimann 1200
MOMBE growth of highly tensile-strained InGaAsP MQWs and their applications to 1.3-μm wavelength low threshold current lasers
H. Sugiura, M. Ogasawara, M. Mitsuhara, N. Yamamoto and M. Itoh 1205
Growth and transformation of ultra-thin InAs/InP layers obtained by chemical beam epitaxy
N. Lebouché-Girard, A. Rudra and E. Kapon 1210
Transient surface states during the CBE growth of GaAs
T. Farrell, D. Hill, T.B. Joyce, T.J. Bullough and P. Weightman 1217
Be redistribution in InGaAs and InP grown by gas source molecular beam epitaxy
T. Mozume and K. Hosomi 1223
Growth temperature-dependent conduction-type inversion of C-doped InGaAs grown by chemical beam epitaxy
Jeong-Rae Ro, Sung-Bock Kim, Seong-Ju Park and El-Hang Lee 1231
Selective area etching of III–V semiconductors using TDMAAs and TDMASb in metalorganic molecular beam epitaxy chamber
K. Yamamoto, H. Asahi, T. Hayashi, K. Hidaka and S. Gonda 1236
Indium surface segregation during chemical beam epitaxy of $Ga_{1-x}In_xAs/GaAs$ and $Ga_{1-x}In_xP/GaAs$ heterostructures
M. Mesrine, J. Massies, C. Deparis, N. Grandjean, E. Vanelle and M. Leroux 1242
Full gaseous source growth of separate confinement MQW 1.55 μm laser structures in a production MOMBE
M. Popp, H. Heinecke, H. Baumeister and E. Veuhoff 1247
GSMBE growth and characterization of $In_xGa_{1-x}As/InP$ strained-layer MQWs in a P-i-N Configuration
Wang Xiaoliang, Sun Dianzhao, Kong Meiying, Hou Xun, Zeng Yiping 1254
Symmetric triangular-barrier optoelectronic switch (S-TOPS) by gas source MBE
H. Sakata, Y. Nagao and Y. Matsushima 1259
Chemical beam epitaxy growth of tensile-strained GaAsP/GaAlAs quantum well heterostructures for laser application
J.Ch. Garcia, A. Lebkiri, A. Fily, Ph. Collot, J. Massies and M. Leroux 1265

SECTION XVIII. MBE GROWTH CHARACTERIZATION AND ANALYSIS

Contamination in molecular beam epitaxy: the role of arsenic drag effect
Z.R. Wasilewski, S.J. Rolfe and R.A. Wilson 1270
Photoluminescence and X-ray characterization of relaxed $Si_{1-x}Ge_x$ alloys grown on silicon on insulator (SOI) and implanted SOI substrates
M.A. Chu, M.O. Tanner, F. Huang, K.L. Wang, G.G. Chu and M.S. Goorsky 1278
Modulated-beam studies of the layer-by-layer etching of GaAs(0 0 1) using $AsBr_3$: identification of the reaction mechanism
J. Zhang, O.P. Naji, P. Steans, P. Tejedor, T. Kaneko, T.S. Jones and B.A. Joyce 1284
Morphology of MBE grown InAs films studied by atomic force microscope
Y. Wang, Y.N. Sheng, W. Ge, J. Wang, L.L. Chang, J. Xie, J. Ma and J. Xu 1289
Luminescence anomaly in band gap tailored $In_{0.53}(Ga_xAl_{1-x})_{0.47}As$ quaternary alloy grown by molecular beam epitaxy
A. Ramam and S.J. Chua 1294
Full wafer optical characterisation of resonant tunnelling structures using photoluminescence excitation spectroscopy
P.D. Buckle, P. Dawson, M. Missous and W.S. Truscott 1299

Scanning tunneling spectroscopy and first-principles investigation on GaAs(0 0 1)(2 × 6)-S surface formed by molecular beam epitaxy
S. Tsukamoto, T. Ohno and N. Koguchi 1303
Does scanning tunnelling microscopy provide a realistic picture of the step array of vicinal GaAs(0 0 1) surfaces grown at high temperature?
L. Däweritz, H. Nörenberg, P. Schützendübe and K.H. Ploog 1309
Substrate temperature change in III–V molecular beam epitaxy
K.R. Evans, J.E. Ehret, C.R. Jones and R. Kaspi 1316

Author index 1321

Subject index 1341